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PROVISIONAL SCIENTIFIC INTELLIGENCE REPORT

THE SOVIET SECOND-GENERATION INTERCONTINENTAL BALLISTIC MISSILE, SS-7

NOTICE

The data and conclusions of this finished intelligence report are provisional and do not necessarily reflect the final position of the Office of Scientific Intelligence. Nevertheless, the material is being published at this time for use by the Intelligence Community until a firm estimate can be established.

OSI-PR/SC/63-2
3 July 1963

CENTRAL INTELLIGENCE AGENCY

Office of Scientific Intelligence

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PREFACE

Late in 1960 or early in 1961, the Soviets began research and development firings of their second generation intercontinental ballistic missile weapon system, SS-7.* Since that time, they have fired at least 49 SS-7 intercontinental ballistic missiles, including seven successful 6,500-nautical-mile firings to the mid-Pacific impact area. Sufficient data are now available to define with reasonable accuracy the gross technical and operational characteristics of this new Soviet weapon system. This report contains additional analysis to that published in the Scientific Intelligence Memorandum, The Soviet Second Generation ICBM System, dated 5 January 1962, and supersedes that report.

Inputs to this analysis have been provided from various technical intelligence collection media and clandestine reporting. The primary technical intelligence input resulted from analysis of telemetry intercepted from the missile in flight. Photographic coverage has provided valuable information on launch site characteristics. Additional data have been obtained from optical coverage of the mid-Pacific re-enteries, radar intelligence, and photographic coverage of the Tyuratam Missile Test Range. Confidence in the overall analysis is high although there are a number of gaps that continue to exist with respect to specific areas. The cutoff date for information in this report was 1 February 1963.

*Designation given by U.S. intelligence.

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THE SOVIET SECOND-GENERATION INTERCONTINENTAL BALLISTIC MISSILE, SS-7

PROBLEM

To determine the technical and operational characteristics of the Soviet second generation intercontinental ballistic missile, SS-7.

CONCLUSIONS

1. The USSR has developed, tested, and is now deploying the SS-7,* a second generation intercontinental ballistic missile system with advanced characteristics. Thus far, eight soft and seven hard launch sites have been detected at 13 locations. The system has been developed rapidly and operational site construction has taken place concurrently with the research and development effort. System development has been conducted at an exceptionally high priority by a highly qualified Soviet team, a team that probably gained experience on three other extremely successful advanced-designed missile systems.

*Designation given by U.S. intelligence.

2. The technical characteristics of the SS-7 intercontinental ballistic missile system are:

Configuration	Tandem, 2 stage
Gross weight at liftoff	260.000 ± 40,000
Re-entry vehicle	Ablative, sphere-cone design, weight 4,500 ± 1,000 pounds
Warhead weight	3,500 ± 1,000 pounds
Propulsion system	Probably 3 engines - 1st stage Probably 1 engine - 2nd stage Probably 4 control motors - each stage
Propellants	Red fuming nitric acid or nitrogen tetroxide and hydrazine/UDMH** or similar
Guidance	Probably preprogrammed inertially for controlled-pitch and velocity profile, with azimuth control by either inertial elements or possibly radio

**Unsymmetrical dimethyl hydrazine.

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3. The operational characteristics are estimated as:

Range	6,000 nautical miles (non-rotating earth)	
Accuracy	1 to 1.5 nautical miles CEP	
Reliability	Ready missile rate	- 85 percent
	One launcher	- 85 percent
	Inflight	- 90 percent
	Overall	- 65-70 percent
Reaction time	Nonalert condition	- 10 hours
	Maximum readiness condition	- 5-15 minutes

4. The known existence of at least eight soft launch sites either completed or under construction during 1961 and 1962, while the missile system was still in research and development testing, testifies to the concurrency and priority assigned to the deployment of the SS-7 weapon system. Each of the soft deployment sites has at least four separate road-served launch complexes connected to a rail-served support area. Each launch complex includes two flat concrete pads patterned after launch complex C of the Tyuratam Missile Test Range. Initial operational capability existed in early 1962 at these soft launch sites.

5. The SS-7 is being deployed to at least seven silo-type hard launch site locations in the USSR. Initial operational capability in this mode occurred in late 1962. These road-served sites have two launch silos about 200 feet apart supported by a single underground control center. Whether the missiles will be launched from the silo or raised to the surface for launch has not been determined.

DISCUSSION

Introduction

After a decade of research and development effort involving ballistic missiles of 150, 300, 650, and 1,100-nautical-mile ranges, the Soviets had the first successful flight test firing of their first generation intercontinental ballistic missile (ICBM), the SS-6* in late 1957. The SS-6 is a large 500,000-pound gross weight, parallel or partial-staged vehicle capable of delivering an 8,000-pound re-entry vehicle some 6,000 nautical miles. It utilizes nonstorable liquid oxygen and kerosene as propellants. An initial operational capability was probably achieved by early 1960. It is believed, however, that significant deployment of the system did not occur, as the Soviets probably realized in 1958 the improved characteristics that could be incorporated in an ICBM.

[redacted] after some 30 firings of the SS-6 vehicle, the Soviets succeeded in launching a second generation intercontinental ballistic missile. There are indications, however, that an earlier attempt to launch the SS-7 [redacted] resulted in an on-pad failure. This second generation system, designated the SS-7 ICBM, is relatively small (260,000 pounds) and is a tandem, two-stage vehicle. Its development has been rapid and highly successful, and deployment of the system has been concurrent with the research and development firings. Figure 1 illustrates the firing program of this weapon system to date. Almost 3 years were required to accomplish the same number of firings of the SS-6 that the SS-7 system accumulated in about one and one-half years. On the basis of a highly successful flight test program and the concurrent soft site construction, it is believed that an initial operational capability was achieved during the first half of 1962. Initial firings from the silo-type launcher of two SS-7 ICBM's [redacted] and the concurrent construction program of silo-type sites in the field are consistent with initial operational capability of the SS-7 in late 1962 in the hardened mode. 25X1 25X1 25X1

*Designation given by U.S. intelligence.

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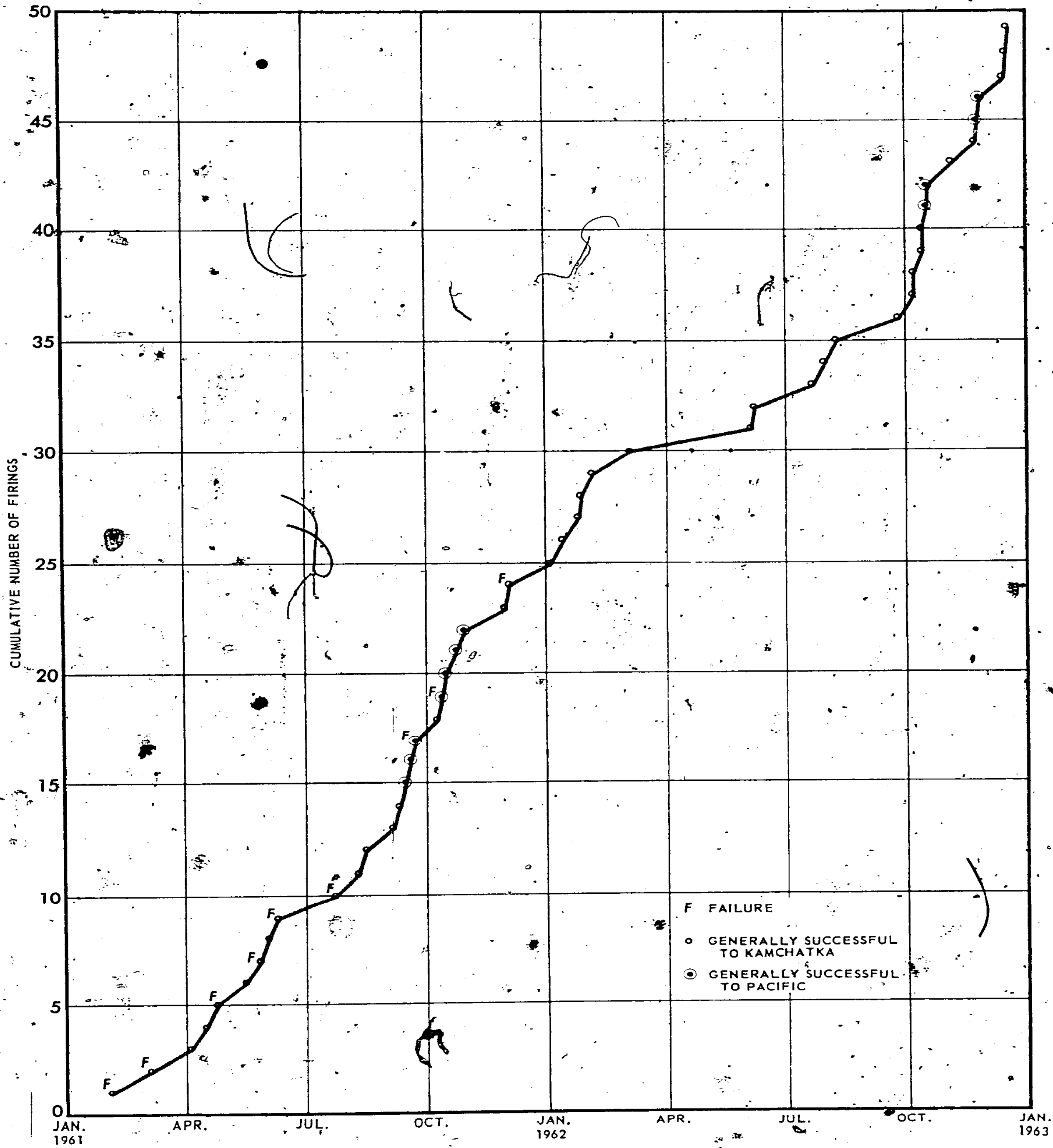

Figure 1

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TEST FIRING PROGRAM ON THE SS-7 ICBM

The rapidity of its development may be due in part to an apparent close relation between characteristics of this system and the 2,200-nautical-mile Soviet IRBM (the SS-5). The IRBM flight tests were initiated in June 1960 on the Kapustin Yar Missile Test Range. The same design team may have been involved in both of these systems and two other highly successful programs, the 1,020-and the 150-nautical-mile ballistic missile systems.

Technical Characteristics

Configuration and Sizing.--The SS-7 ICBM was identified as a two-stage configuration soon after the first staging intercept of telemetry was obtained [redacted] This and subsequent intercepts have revealed not only staging time, but also an accurate approximation of first stage and final thrust termination times and re-entry vehicle separation time. Two staging arrangements are possible that would give a telementry indication of a tandem vehicle: (i) two in-line stages like the U.S. Titan ICBM or (ii) a parallel arrangement in which the second stage is carried aloft by two or more concentrically arranged booster stages. Telemetry evidence and the analysis of photography of an SS-7 ICBM erected at Tyuratam launch area C, however, indicate an in-line arrangement.

The sizing derivations of the SS-7 missile are listed in table 1 along with the assumptions used. They are based on the 4,500-pound nosecone, on photographic analyses, and on telemetry derived ratios. The weight, thrust, and flow rate schedule derived from these data is given in table 2.

Studies of empirical data from both U.S. and Soviet missiles have shown that there is a relationship between the propellent sloshing oscillations and the missile tank diameter.*

*Project Westwing.

This relationship is described by the equation:

$$\frac{f^2}{a} = \frac{1.84}{r}$$

where: f = frequency of propellant slosh oscillations
a = acceleration of gravity (32.2 ft/sec^2)
r = tank radius

The observed frequency of propellant sloshing oscillations in the second stage of the SS-7 ICBM has a mean value of 3.85 cycles per second. The application of this value in the relationship stated above results in a diameter of 8 feet for the SS-7 second stage. From this value for diameter, the given nosecone weight and the weight, thrust, and flow rate schedule derived in table 2, the entire missile may be sized. For example, the second stage flow rate of 645 pounds per second multiplied by the burning time of the second stage, 114 seconds, gives the total propellant weight of 73,500 pounds that is consumed during the second stage operation. Assuming that this value represents the approximate total amount of propellants and that these propellants are red fuming nitric acid and hydrazine/UDMH mixture having a combined bulk density of 78.6 pounds per cubic foot, the volume of the tankage is then approximately 930 cubic feet. Again, assuming that this volume is contained in a cylindrical section, with a diameter of 8 feet, the tankage length is calculated to be about 18 feet. However, because telemetry data and photo analysis indicate that the upper portion of this tankage is tapered and the length value calculated for a cylindrical section, therefore, would be increased slightly to enclose the same volume, it is estimated that the upper tank length is about 20 feet. On the other hand, if the propellants are nitrogen tetroxide with hydrazine/UDMH, which has a bulk density 5 percent lower than the RFNA/hydrazine/UDMH mixture, the total tankage length would be increased by approximately 5 percent. 25X1

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The length of the first stage was similarly calculated, based on a diameter of 10 feet, and was found to be approximately 30 feet.

Added to these tankage lengths, the estimated length for nosecone, guidance, and propulsion systems result in an overall length for the SS-7 ICBM [redacted] The probable schematic layout of the SS-7 ICBM is shown in figure 2.

Propulsion System and Propellants.--The propulsion system for the SS-7 ICBM is believed to consist of three main engines on the first stage, and a single main engine on the second stage. All engines use liquid propellants, and each stage probably employs four control motors.

Propulsion data for the first stage of the SS-7 does not permit a positive determination of the system characteristics. However, measurement parameters are largely in groups of three, suggesting that the first stage propulsion system includes three engines. It is not known if thrust control is used on the first stage engines.

The existence of control motors on the first stage is somewhat unusual, and a satisfactory reason for their use cannot be determined from the limited telemetry intercept of the first stage operation. Sufficient data are not available to ascertain whether any gimballing of the first stage main engines occurs. This seems unnecessary, however, because the control motors may be furnishing a total of as much as 38,700 pounds.

Sea level thrust of the first stage engines is believed to be about 460,000 pounds (the thrust/weight ratio is on the order of 1.77). The first stage control motors furnish about 8 percent of this thrust, which means that each of the three first stage main engines is furnishing around 148,000 pounds of thrust. Also, a vacuum Isp of 270 seconds has been determined for this stage.

The second stage propulsion system probably has only one main thrust chamber and one main turbopump, because the second stage propulsion system has only one measurement each of the main engine chamber pressure and turbopump speed. The second stage main engine is thurst controlled. The general characteristics of the second stage control system attitude error and actuator position channels are similar to those of the SS-6 ICBM and, therefore, it appears likely that second stage missile attitude control is maintained with four control motors, each having a single-degree-of-freedom for thrust vector control. For this reason, the second stage thrust chamber is probably fixed in position. The control motors provide an average of 5.5 percent of the total second stage thrust, or about 2,500 pounds of thrust each. The second stage main engine furnishes about 174,000 pounds (vacuum) thrust, and the second stage control motors provide an additional 10,000 pounds; the total second stage thrust, therefore, is about 184,000 pounds.

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The staging and final shutdown sequence of the vehicle are shown graphically in figure 3. The first stage control motors do not shut down until after full thrust is obtained with the second stage control motors. The fact that the second stage control motors are ignited prior to the second stage main engine and reach full thrust just prior to stage separation tends to indicate that they may be used to effect the separation. Second stage main engine cutoff normally occurs around 201 to 202 seconds, with the control motors continuing until about 210 seconds. Simultaneous with the control motor cutoff, four solid propellant retrorockets attached to the second stage are fired to provide positive separa-

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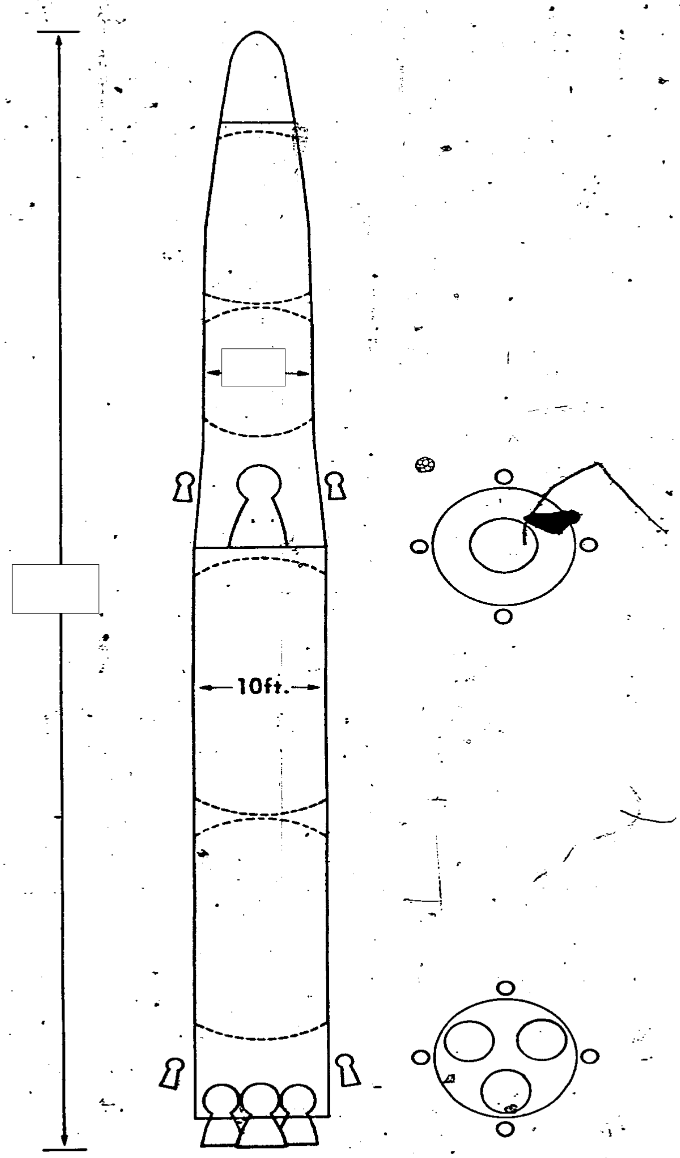

Figure 2

SCHEMATIC OF PROBABLE SS-7 ICBM CONFIGURATION

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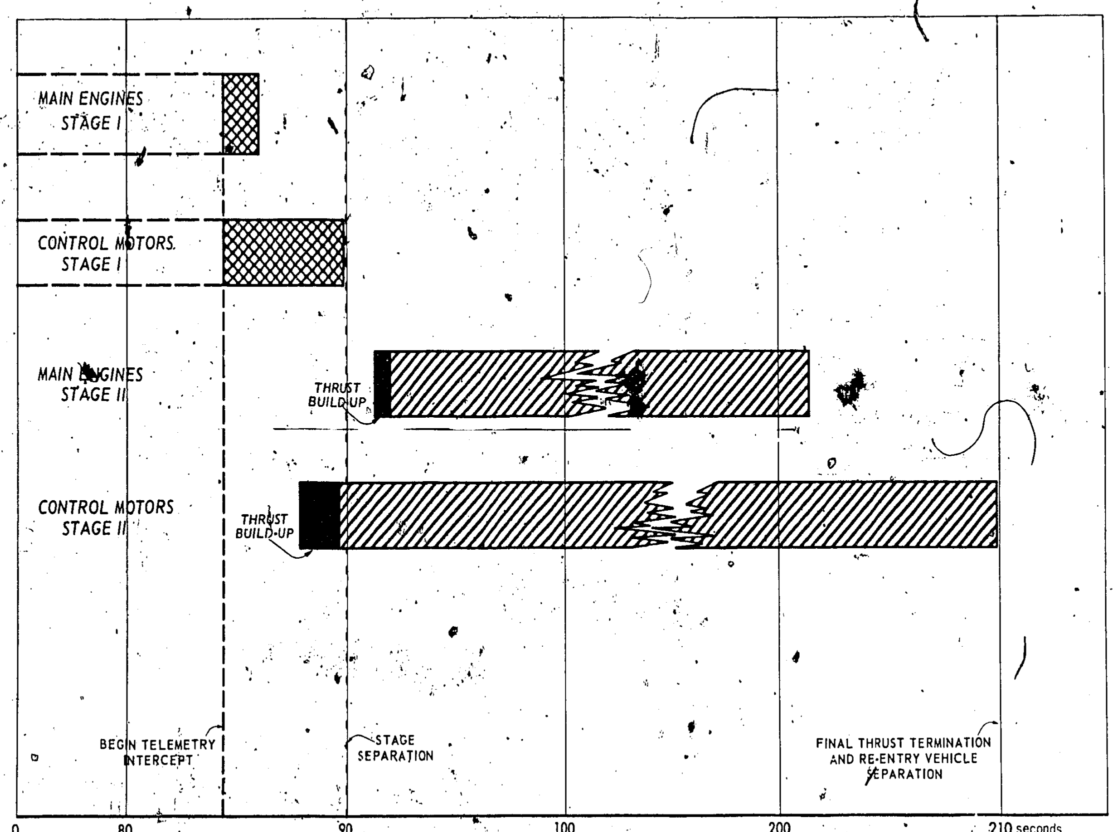

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Figure 3
STAGING AND FINAL SHUTDOWN SEQUENCE OF THE SS-7 ICBM ON 17 JANUARY 1962

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tion between the second stage structure and the re-entry vehicle. The retrorockets operate for 0.56 seconds; and following release of the re-entry vehicle, the net thrust on the after-body is about minus 1g for 3,500-nautical-mile firings.

A second stage vacuum specific impulse (Isp) of 290 ± 3 seconds and an average propellant volumetric mixture ratio of 1.2 have been computed from telemetry. Some of the more common propellant combinations that satisfy the above conditions of volumetric ratio and Isp are:

Oxidizer	Fuel
Nitrogen Tetroxide	UDMH
Nitrogen Tetroxide	50 percent Hydrazine/50 percent UDMH
Red Fuming Nitric Acid	UDMH or 50 percent Hydrazine/ 50 percent UDMH
Lox	92.5 percent Ethyl Alcohol

Of these propellant combinations, the Lox-alcohol combination does not appear to be reasonable because if a decision were made to continue using liquid oxygen as the oxidizer, there would have been no need to suffer the reduction in performance resulting from a switch to liquid alcohol from kerosene which was used in the SS-6. Therefore, it is considered more likely that either nitrogen tetroxide or red fuming nitric acid is used as the oxidizer. Either UDMH or a 50 percent mixture of UDMH/hydrazine are more likely as the fuel because of the greater compatibility with the evidence and improved temperature characteristics in comparison to hydrazine alone. In any event, the propellants for the SS-7 ICBM system appear to be completely storable and thus afford the Soviets many advantages over the cryogenic oxidizer used with the SS-6 ICBM.

The SS-7, like every other Soviet missile from which telemetry has been intercepted, has exhibited the use of thrust control. Thrust control is fundamental to the Soviet guidance philosophy which is based upon a rigidly and tightly constrained missile velocity and trajectory profile. This philosophy cannot be employed without the ability to vary the thrust amplitude. This thrust control technique relaxes guidance system (computer) requirements but increases the requirements imposed on the propulsion system. U.S. technology has tended to follow an opposite technological course, using constant thrust and relatively loose trajectory constraints thus placing a considerable burden on the guidance system computer to achieve the proper missile flight dynamics that will ultimately place the warhead on target.

Guidance and Control.--The evidence is not conclusive as to the guidance system employed in the SS-7 missile. However, (1) the lack of any evidence in support of the presence of a radio component in the guidance system, (2) the large number of inertial components on board the vehicle, (3) the existence of evidence which tends to support a greater Soviet capability in inertial systems than heretofore believed likely, and (4) the expectation that in this second generation ICBM system the Soviets would attempt to create as many operational advantages as possible lead to the belief that the guidance system is heavily, if not totally, dependent on inertial techniques. If employed, the use of radio command for inertial override is probably accomplished on a minimal basis in the yaw plane to provide greater azimuthal accuracy. Although there is little evidence to support the contention, radio override may have been used during the early testing of this missile with later tests being concerned with all-inertial type. A thorough investigation has been made into guidance related telemetry channels in an attempt to determine if there is a stable platform used in this missile and to determine the nature of several telemetry channels with pulse rates apparently corresponding to missile thrust acceleration. The investigation disclosed eight channels of telemetry that monitored various related functions of missile acceleration. Detailed correlation of these channels has revealed that redundancy exists between two pairs of the channels. Three digital accelerometers, a folded scale accelerometer, an analogue accelerometer, and a programmed velocity trace have been identified. The analogue accelerometer is probably used as instrumentation.

[redacted]

As with most other Soviet ballistic missiles, the thrust control system of the SS-7 is an integral and critical component of the guidance system. The time repeatibility of the second stage main engine cutoff is within a fraction of a second from flight to flight. In addition, a velocity program channel is evident in telemetry, suggesting tight control of the powered-flight trajectory to a preset velocity profile. This control is accomplished by using the difference between this velocity program and one or more of the digital velocity meter measurements to generate commands for the thrust control system.

No evidence is available to indicate the presence of radio component in the SS-7 missile guidance system. Furthermore, reconstruction of trajectories from FLIM FLAM* data for the two SS-7 firings [redacted] indicate 25X1 that they were both launched from launch area D at TTMTR, which contains silo launchers. (See figure 4.) No radio guidance facilities have been identified in the vicinity of the launch facilities at TTMTR from which SS-7 missiles have been fired nor has any such facilities been detected at the deployed sites.

An available Soviet report describes operational training aids necessary for an ICBM with an "autonomous" or "self contained" guidance system. This "self contained" system is probably used on the SS-7 in view of the strong indications of a radio component in the SS-6 and the SS-8 guidance systems and the lack of it in the SS-7.

Re-entry Vehicles.--Two sources of information are available to determine the characteristics of the re-entry vehicle for the SS-7 ICBM. These are the 1961 Pacific firings of the missile and the 1958 and 1961 Soviet nuclear tests. Telemetry and optical coverage of the re-entering vehicle along with trajectory data[3] have permitted a fairly accurate determination to be made of a number of parameters.

*Code name applied to intercepted Soviet tracking data.

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The ballistic coefficient (W/C_dA) or weight/drag ratio of the re-entering body may be obtained from a knowledge of:

a. Time of impact as determined from final telemetry loss time.

b. Time of transonic passage as determined from telemetry channel interpretation.

c. Time of telemetry signal emergence from the radio "blackout" period; (a point which denotes an approximate Mach 10 velocity).

d. Re-entry conditions (speed and angle of re-entry).

For a particular set of re-entry conditions, the time between (a) and (b) and/or (a) and (c) above are unique to a particular value of ballistic coefficient. Figure 5 is a time versus ballistic coefficient plot of (a), (b), and (c) based on the Pacific tests re-entry conditions. The vertical lines are drawn on the figure at times corresponding to the observed events. Because impact time is believed to be the most exact data point available, this figure is plotted with that as a common point for all values of ballistic coefficient. The lines of constant altitude or Mach number are then placed with respect to time from impact. It is observed that all of the data points given are quite consistent and can be satisfied by the selection of a hypersonic ballistic coefficient of about 1,125 pounds per square feet. This agreement in altitude-time correlation is essential for a confident approach to the re-entry vehicle sizing analysis.

Upon re-entry, the luminous intensity of the hot gas layer surrounding a re-entering vehicle is a function of its angle of attack, among other things. Examination of the optical data from the Pacific firings, points out these luminous peaks as they occur with time, giving the frequency of vehicle oscillation. Taking this input and combining it mathematically with the ballistic coefficient, the atmospheric entry conditions (see figure 6) as derived from the computed free-flight trajectory, and the resultant dynamic pressure time history results in a determination of the stability parameter of the body. This stability parameter along with the ballistic coefficient serves as key inputs into the determination of size.

In approaching the sizing analysis, a basic sphere-cone re-entry vehicle shape is considered, and an attempt is made to construct a vehicle whose performance matches the data observed in the Pacific firings. The performance data to be matched are related basically to the vehicles's ballistic coefficient and its oscillation frequency versus time history as observed by optical coverage.

This same method of analysis, that is, assuming a sphere-cone design, was undertaken for the SS-6 ICBM re-entry vehicle; and it was shown that this approach was indeed valid. Since then, more data of a similar nature on U.S. hemisphere-cone-cylinder-flare-type re-entry vehicles has been analysed and found to exhibit average aerodynamic moments versus angle of attack nonlinearities which appear to give this class of vehicle a distinctive re-entry signature. This feature sets them apart from the linear sphere-cone family thereby adding further confidence to this analysis.

The method of analysis relates certain lumped parameters (principally the ballistic coefficient and the stability parameters), derived from the Pacific firings, and empirical parameters, derived from U.S. re-entry vehicle research, to the geometrical properties which specify a particular sphere-cone configuration (nose radius, base radius, and cone angle). It has been found that the available data plus additional physical constraints, which appear due to the application of reasonable engineering design criteria to re-entry vehicle construction,

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yield a configuration of surprisingly small tolerance. Preliminary analysis of two out of the five Pacific firings of 1961 has indicated [redacted] 25X1 ure 7.) The weight of the re-entry vehicle is indicated to be about 4,500 pounds. The above analysis also satisfies the criteria for the initially assumed sphere-cone configuration but presents deficiencies with regard to the observed stability parameter when compared to that of a hemisphere-cone-cylinder-flare design.

Additional credence is lent the above figure of weight by data derived from the Soviet nuclear tests of 1958 and 1961. The 1958 tests revealed a high interest in developing and improving the 3,500-pound weapon class. The 1961 tests reflected the improvement with a somewhat increased yield-to-mass ratio. The previous independently derived re-entry vehicle weight of about 4,500 pounds is compatible with a warhead of this weight.

The ballistic coefficient (1,125 pounds per square foot), which is indicative of a fast re-entry, and the optical coverage, indicating a surface temperature of 3,000° K, clearly illustrate that the SS-7 re-entry vehicle is an ablative type. Although the ablative material has not yet been defined, it is, quite likely, a similar material to that used on the re-entry vehicle of the SS-6 ICBM. The SS-6 re-entry vehicle was notably different from U.S. ablative cones in that indications of metals and metallic oxides (predominatly alumimum and magnesium) appeared almost exclusively in the spectral analysis. U.S. designs lean heavily toward organic types of materials which were almost totally lacking in the SS-6 ICBM re-entries.

Figure 8 shows the telemetered re-entry vehicle functions at re-entry obtained from one firing of the 1961 Pacific series. Other than the event markers on channels 8 to 12--the associated approximate altitudes and the transonic bump on the base pressure measurement--these telemetered parameters are not conducive to interpretation of arming and fuzing techniques. The activity noted is probably indicative of sequential functions in the arming and fuzing operation; but without knowledge of the channel identities, the events are meaningless. However, the transonic bump indicated is a significant input to the intelligence interpretation of the ballistic coefficient previously discussed.

Recently acquired re-entry data have indicated that the Soviets have been testing a new re-entry vehicle on the majority of the SS-7 tests [redacted] This has been 25X1 indicated specifically by:

a. A change in format in the 66 megacycle re-entry data.

b. Subsonic impact of the re-entry vehicle on Kamchatka instead of the previous supersonic impact.

c. Analysis which indicates that the new re-entry vehicle ballistic coefficient is approximately 900 pounds per square foot rather than the 1125 pounds per square foot previously obtained. Definitive calculations of the weight of this new re-entry vehicle have not as yet been possible; however, the limited data available indicate that the weight is not appreciably different.

Performance Characteristics

Trajectory.--The trajectory of the SS-7 has been reconstructed from the 7 June 1962 telemetry intercept. The salient features of the trajectory are:

a. A vertical rise of 4 seconds.

b. A gravity turn during booster burning.

c. A constant attitude from staging to burnout.

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The trajectory was reconstructed by observing that the ratio of acceleration sensed by the platform mounted accelerometer monitored in channel 13 to the roll-axis mounted accelerometer monitored in channel 7 was increasing. This increase indicated that the longitudinal axis of the missile came closer and closer to the sensitivity axis of the channel 13 accelerometer; thus, it is possible to derive a pitch program by adjusting the initial orientation of the channel 13 accelerometer and the pitch program to match FLIM FLAM burnout conditions.

Figure 9 illustrates the derivation of the pitch angle. The sub-numbers indicate the telemetry channel in which the acceleration measurements were made. The pitch angle $\theta_p(t)$ can be calculated if $\theta(t)$ and ξ are known. $\theta(t)$ was measured as $\cos \frac{-1A_{13}(t)}{A_{7}(t)}$; $\theta_p(t)$ and ξ were adjusted until the FLIM FLAM burnout conditions were met. The resultant pitch program is shown in figure 10.

These trajectory studies in coordination with telemetry analysis have revealed that the SS-7 ICBM is a high acceleration vehicle with a concomitant short thrust period. Staging occurs at about 90 seconds after launch with first stage thrust terminating a few seconds prior. Second stage main engine thrust termination occurs about 202 seconds after launch followed by a control engine period of 6 to 10 seconds. Coincident retrorocket separation of the re-entry vehicle takes place at the time of control engine thrust termination. A maximum load of approximately 5.5g is imposed on the vehicle at first stage burnout and 16g at second stage burnout on 6,500-nautical mile firings.

First stage afterbody impact probably occurs within 200 nautical miles of the launch point as contrasted to the 400 nautical mile impact of the SS-6 ICBM boosters.

The Soviet SS-7 vehicle represents a non-optimized design with the velocity gained during the first stage operation being less than one-third that gained after staging.

The pitch program provides an acceptable solution for both the 3,500-nautical-mile (Kamchatka impact) and the 6,500-nautical-mile (mid-Pacific impact) firings. This suggests a possible standard programming of the powered flight profile.

<u>Accuracy.</u>--Two methods have been considered for determining probable operational accuracy of the SS-7. The first involves estimation of the state-of-the-art in guidance system technology modulated by such knowledge as is available from telemetry. No precision is possible with this method. The second method uses intercepted FLIM FLAM data. Although this source does not yield as precise an answer as desirable, because target and data unknowns are involved, it does give an approximate measure of accuracy achieved on the test range.

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reliable impact points; that is, observations which include ample slant range, as well as azimuth and elevation data, from widely separated stations. Only 8 points remain for a sample after deletion of impacts which fall extreme distances (more than three sigma, the criterion for accuracy consideration) from the center of a discernible aiming pattern. See figure 11. The extreme impacts from apparently good data could be caused by guidance and propulsion malfunctions, change in aiming point, or inaccurate processing as a result of tracking data uncertainties. The CEP using the 8 impacts selected is approximately 1.2 nautical miles. If the two impacts [redacted] located about 3 nautical miles from the assumed aiming point (the mean of impacts) are deleted, the CEP is reduced to about 0.7 nautical mile.

STL recently completed an extensive study of the SS-7 accuracy based on FLIM FLAM and have derived, for the most part, a different impact pattern for the SS-7 data which they have processed. As with the NSA analysis, many test dates have been eliminated for data quality reasons (STL's method requires good data from widely separated tracking stations) as well as telemetry evidence for detection of a possible malfunction. The STL impacts indicate the probability of multiple aiming points, although no clear explanation is available. That likelihood is supported by the fact that the ballistic launch points for these tests fall into the same groupings as the corresponding impacts, as well as by a significance test (based on lateral difference between impact means) for a two target probability. The Group I impacts yield a CEP of about 0.65 nautical mile and the Group II impacts a CEP of about 0.93 nautical mile. Group I and II test firings combined, assuming zero instrumentation error (error in the FLIM FLAM measuring system) and two targets, give a CEP of about 0.78 nautical mile. Group III, which include the [redacted] tests, also suggest a third target; but because the sample is small, no independent CEP was derived. If the effect of possible FLIM FLAM instrumentation errors on a calculated CEP is taken into account, with 0.46 nautical mile as the best estimate, it is possible to construct a 90 percent confidence range for missile CEP of 0.47 to 1.02 nautical miles, with the best estimate being about 0.64 nautical mile.

During the Pacific tests (6,500-nautical-mile range) of this missile in September and October 1961, four Soviet *Sibir*-class instrumentation ships were deployed in the impact area. On each of five successful firings of this missile, three of these ships--the *Sibir*, the *Sakhalin*, and the *Suchan*--formed a scalene triangular pattern of which the longest dimension varied between 35 and 50 nautical miles. Despite a slight shift in the overall ship pattern, all of the missiles impacted within the triangular area and generally near the centers of the pattern. A plot showing the relative position of all 1961 Pacific impacts is shown in figure 12. Although this information is meaningless insofar as a determination of the lethality of the weapon system is concerned, it does indicate a gross capability which, considering the limitations of the intelligence data with regard to obtaining an accurate geographical fix, implies at least a reasonable CEP for the weapon system. Although the calculated CEP's range from 0.6 to 1.2 nautical miles (3,400-nautical-mile range), depending on the data processing and error assumptions, in view of the estimated atonomous guidance for the SS-7, a CEP of about the midpoint of this range is more likely, based on state-of-the-art knowledge. These two estimates, guidance and accuracy, are interrelated; and the estimate

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of the guidance system is more certain than the estimate of the accuracy. In general, an all inertial guidance system would be about 50 percent less accurate when fired to 6,000 nautical miles than when fired to 3,500 nautical miles. Until it becomes possible to construct the error coefficient equations for this guidance system, the actual degredation with range will not be determinable.

The operational accuracy of the SS-7 is, therefore, estimated to be 1 to 1.5 nautical mile CEP at a range of 5,000 nautical miles. There would be no significant degradation due to target location, geodetic, or re-entry errors in light of the current assessment of Soviet probable errors in locating U.S. targets and use of fast re-entry bodies.

Reliability.--INFLIGHT -- Eighty-two percent of the SS-7 missiles launched from TTMTR reached the intended impact areas, either on the Kamchatka Peninsula or in the mid-Pacific Ocean; that is, there were 40 generally successful flight tests in 49 launches. However, six of the generally successful flight tests, for which reasonably good FLIM FLAM data are available, impacted outside of a three-sigma deviation value, indicating a possible malfunction. If these six possible malfunctions are taken into consideration, the inflight reliability would be 69 percent. Thus, the possibility of multiple targets and FLIM FLAM data errors probably make this reliability appear worse than it is.

The flight test record of the SS-7 in 1962 is probably more representative of its present reliability. There were 25 generally successful flight tests in 1962 in 25 launches. However, three of these tests, for which acceptable FLIM FLAM data are available, appear to have impacted outside of the three-sigma tolerance. If these three tests are considered as malfunctions, the test range reliability would be 88 percent. Thus, the overall operational inflight reliability of the SS-7 at the present time is probably about 90 percent.

ON LAUNCHER -- Out of 52 launch attempts of the SS-7, for which data is available, there have been 25 missiles launched within 15 to 30 minutes of the scheduled launch time, giving an on launcher reliability of 48 percent for the entire launch time program. During 1962, this reliability was 50 percent. Allowing for delays not caused by the missile system (range operations) will probably give an operational on launcher reliability of about 85 percent.

The ready missile rate for the soft launch site configuration is estimated to be about 65 percent under peacetime conditions and about 80 percent under alert conditions. The hard site configuration will probably have a ready missile rate of about 80 percent under peacetime conditions and about 90 percent under alert conditions. The overall operational ready missile rate is estimated to be about 85 percent.

Reaction Time. --There is no specific information on Soviet ICBM readiness procedures and reaction time; however, from test range and operational launch site layout, it appears that the basic philosophy of operation employed for the SS-7 at soft sites (designated as the SS-7A) would be similar to the MRBM/IRBM operation. Soviet material on the operational procedures for the R-12 (SS-4) missile has been used as a basis for this estimate. It is estimated that the SS-7A (soft) readiness conditions and time to launch from each readiness condition are as follows:

1. Readiness Condition 4. Launch crews not on alert. Missile and re-entry vehicle checked but not mated. Missile in pre-launch storage building. Time to launch--10 hours minimum.

2. Readiness Condition 3. Launch crews in launch area and on alert. Missile and re-entry vehicle mated and checked. Missile in

pre-launch storage building. Time to launch--6 to 10 hours.

3. Readiness Condition 2. Launch crews on station. Missile with re-entry vehicle erected on launch pad, checked, and propellant loading facilities attached. Guidance system set. Time to launch--1/2 to 1 hour.

4. Readiness Condition 1. Launch crew on station. Missile erected and propellant loading completed. Electrical equipment warm and guidance re-checked. Time to launch--5 to 15 minutes.

Because cryogenic propellants are not used in the SS-7, Readiness Condition 1 could be maintained for an extended period of time; however, because erected missiles have not been observed on the completed SS-7A operational sites and because prolonged exposure to the elements would have a deteriorating effect on the missile, it is believed that except during times of national alert, the primary missile force is maintained in Readiness Condition 3.

It is estimated that it would take about 10 hours for the Soviets to launch a second missile from the same launch pad.

The readiness conditions for the SS-7 hard configuration (designated as the SS-7B) are believed to be somewhat different in that Readiness Conditions 4 and 3 are eliminated and that the primary missile force, except during periods of alert, will be maintained in Readiness Condition 2. The time to launch from Readiness Condition 2 and 1 will remain essentially the same as that for the SS-7A.

Site Characteristics, Deployment Concept, and Range Capability.--Photographic coverage of the Tyuratam Missile Test Range in the spring of 1960 revealed the beginning of construction of launch complex C. (See figure 13.) Until the completion of this new area, probably in late 1960, the only launch complexes available at Tyuratam were launch complexes A and B, each of which consisted of a massive rail-served pad built on the edge of an equally massive man-made pit. It is from these launch areas, A and B, that the firings of the large SS-6 ICBM have occurred.

Although launch complex C in the 1960 coverage was in a preliminary stage of construction, it was sufficiently far along to reveal two road-served flat concrete pads as opposed to the single rail-served pads with large pits at areas A and B. Enough detailed outlines of rail and road beds, security fencing, missile checkout building, and so forth were available to permit an artist to complete a sketch of the probable final concept shown in figures 14 and 15. It was obvious from the small size of the launch pads and the rail-to-road transfer point that a smaller vehicle was shortly to enter research and development firings from Tyuratam. A very rough indication of the relative size of the missile was obtained from photographic analysis of the drive-through missile checkout building. The missile checkout building at complexes A and B are 395 feet and 285 feet long respectively. The counterpart building at complex C is only 257 feet long. Although this represents some indication of smaller size, the relative height of these three high-bay-type buildings is a better indication of the relative missile size since the rail car and overhead crane height requirements should represent something of a constant. In vertical dimensions, therefore, it is found that the buildings at complexes A and B measure 70 feet and 75 feet high respectively, while those at complex C measures only 60 feet high.

Although there are indications that the first SS-7 launching was attempted in October 1960 and resulted in a failure, the first SS-7 launch to be confirmed by a telemetry intercept did not occur [redacted] This test 25X1

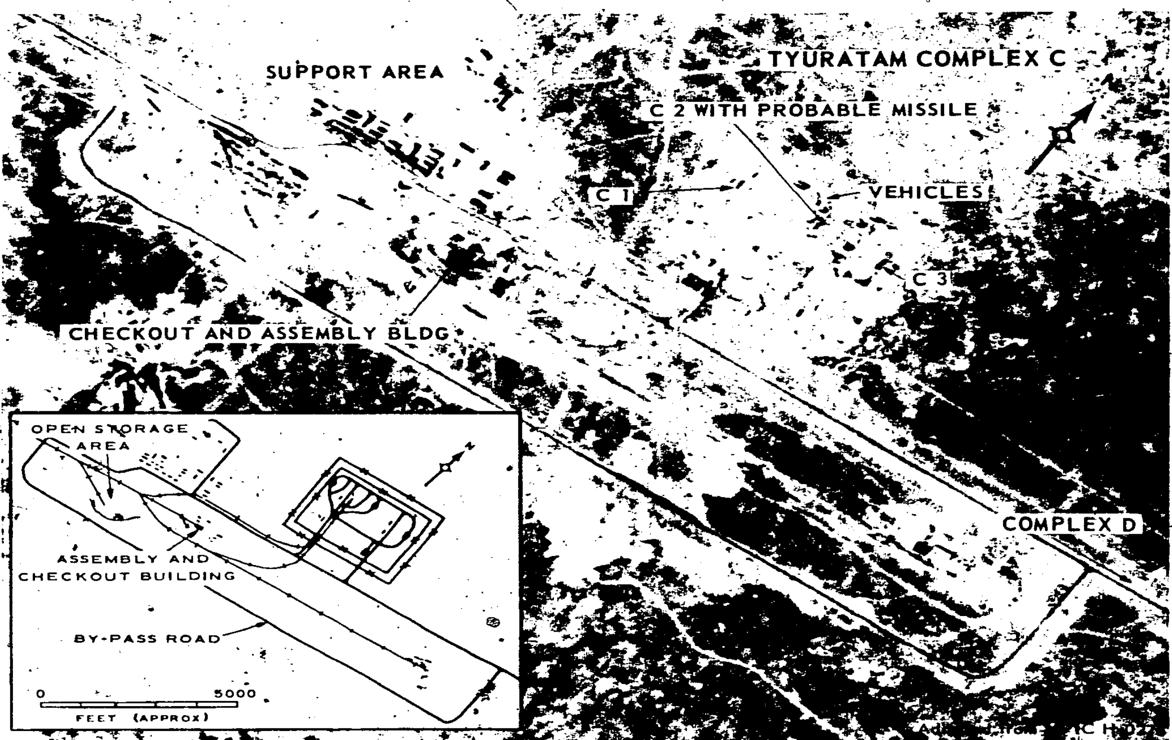

Figure 13
LAUNCH AREA C, TYURATAM MISSILE TEST RANGE

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[redacted] 25X1

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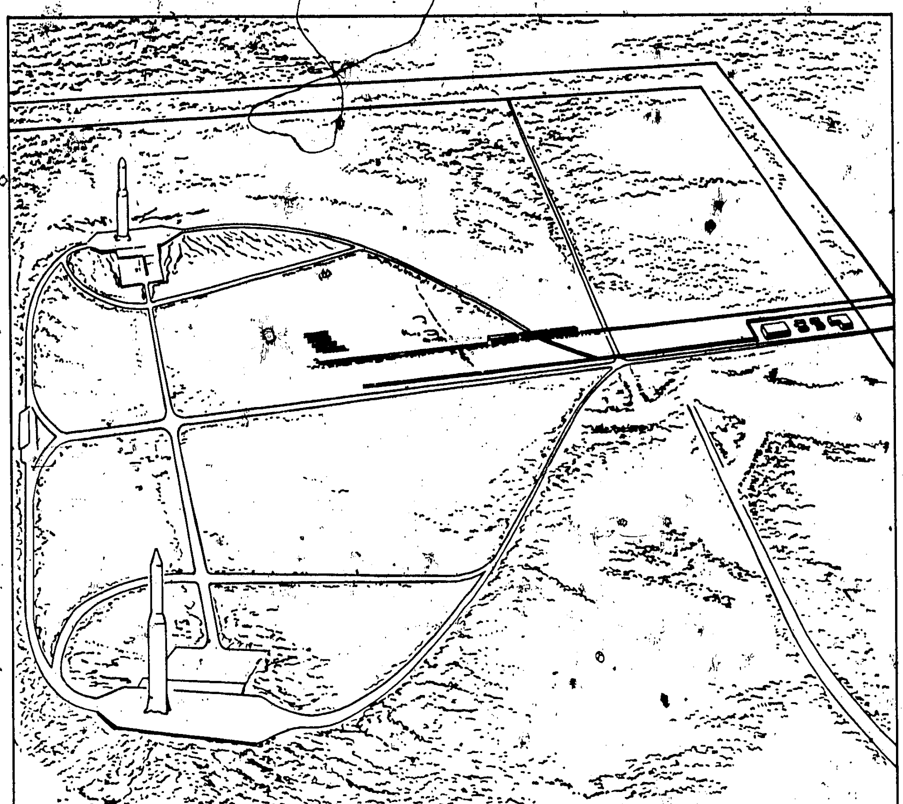

Figure 14.

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ARTISTS CONCEPT OF AREA C
PRIOR TO ADDITION OF THIRD LAUNCH PAD

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25X1

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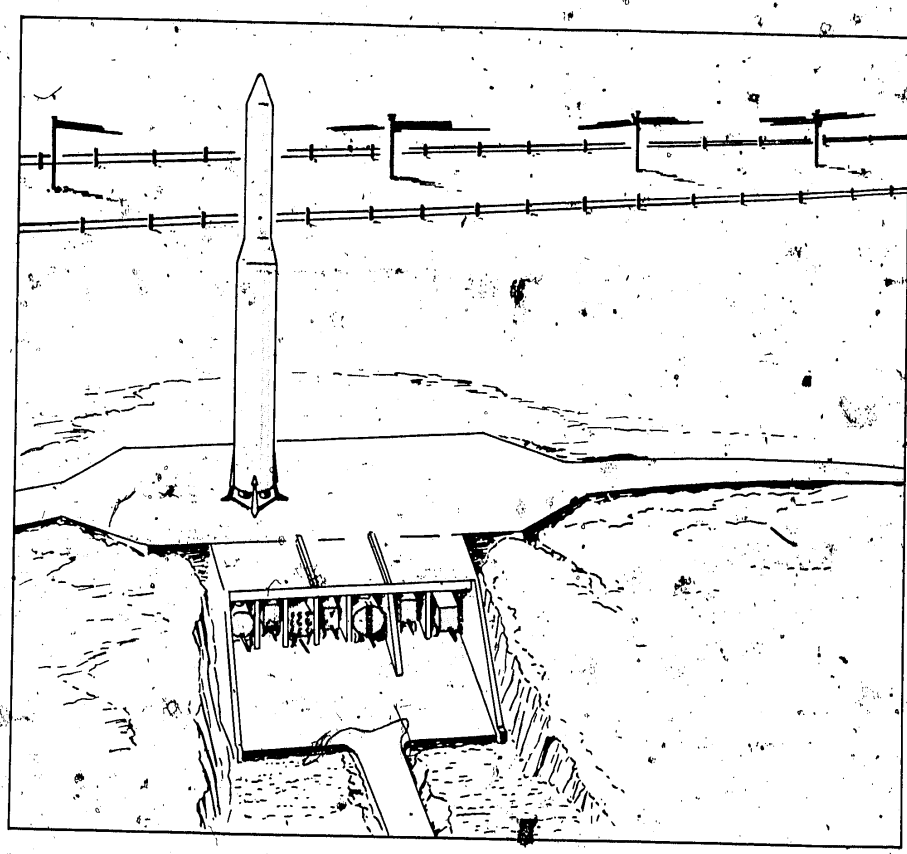

Figure 15.

ARTISTS CONCEPT OF AREA C SHOWING ROAD-SERVED SIMPLIFIED FLAT LAUNCH PAD WITH BELOW-LEVEL STALLS FOR CHECKOUT VEHICLES FOR THE OPERATIONAL SECOND GENERATION SS-7 ICBM

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as well as the next one on 3 March resulted in in-flight failures but confirmed the completion of complex C. The firings continued at a rapid pace throughout 1961 and 1962, with only sporadic lulls in the program.

Photographic coverage that began in September 1961 indicated that deployment of the SS-7 was intended on sites which appear quite similar to the Tyuratam launch complex C facility. To date, these sites have been reported at Yur'ya, Verkhnyaya Salda, Kostroma, Yoshkar-Ola, Itatka, Omsk, Shadrinsk, Yodrova, Perm, Novosibirsk, Svobodnyy, Drovyanaya, and Teykova. These sites, which are plotted on the map, figure 16, reveal an apparent pattern of deployment across the USSR between 50° and 60° north latitude.

The soft launch sites at these locations have two launch pads--the shape, orientation, and separation distance of which are very much like the two pads located at Tyuratam complex C. The most noticeable similarity between the two facilities is the use of road-served launch pads and a probable rail-to-road transfer point. The geographic location of these deployment sites provides a strong argument against any intended use for MRBM or IRBM deployment. Instead, it seems obvious that their locations were chosen to allow target selection in the United States. The apparent northerly firing azimuth also suggests a coverage of U.S. targets rather than European targets. The 6,000-nautical-mile (non-rotating earth) range of the SS-7 permits coverage of all U.S. targets from these sites.

It appears as though each launch complex will be comprised of approximately eight launch areas, some of which will be hard, joined by roads to a central rail-served support area. The soft facilities probably would be damaged by an overpressure exceeding 2 pounds per square inch. These areas are about 4 nautical miles apart. The eight launch areas indicate a capability of at least 16 missiles per deployment complex, and this may define the pattern for Soviet deployment of the SS-7 weapon system in this mode.

Launch complex D at the Tyuratam Missile Range consists of two dual-silo-type launch site installations, located approximately 14 miles east of launch complex C. (See figure 17.) It is believed to represent a hardened launch mode for the SS-7 missile.

Analysis of FLIM FLAM data has indicated that the two SS-7 ICBM's launched within [redacted] were launched from launch complex D. Their ballistic launch points are displaced relative to launch complex D at Tyuratam at approximately the same distances and direction as had been the displacement of prior SS-7 vehicles launched from launch complex C, suggesting that complex D reached an operational status as of that date. (See figure 4.) [redacted] the SS-7 had always been launched from complex C, a conclusion based primarily on FLIM FLAM data backtrack. Previous ballistic launch points for the SS-7 lie about 6 nautical miles behind complex C with the mean offset near the firing azimuth from complex C to Kamchatka. Most clustered within a 2-nautical-mile circle.

The FLIM FLAM data for both the [redacted] firings are of good quality because the slant range, azimuth, and elevation data were obtained from two widely separated tracking stations. The ballistic impacts for these firings fell in the usual Kamchatka impact area, indicating that there was no large guidance error which could degrade the validity of the backtrack. Provided that there was no large yaw maneuver, the derived ballistic launch points strongly indicate that the actual launch took place from complex D.

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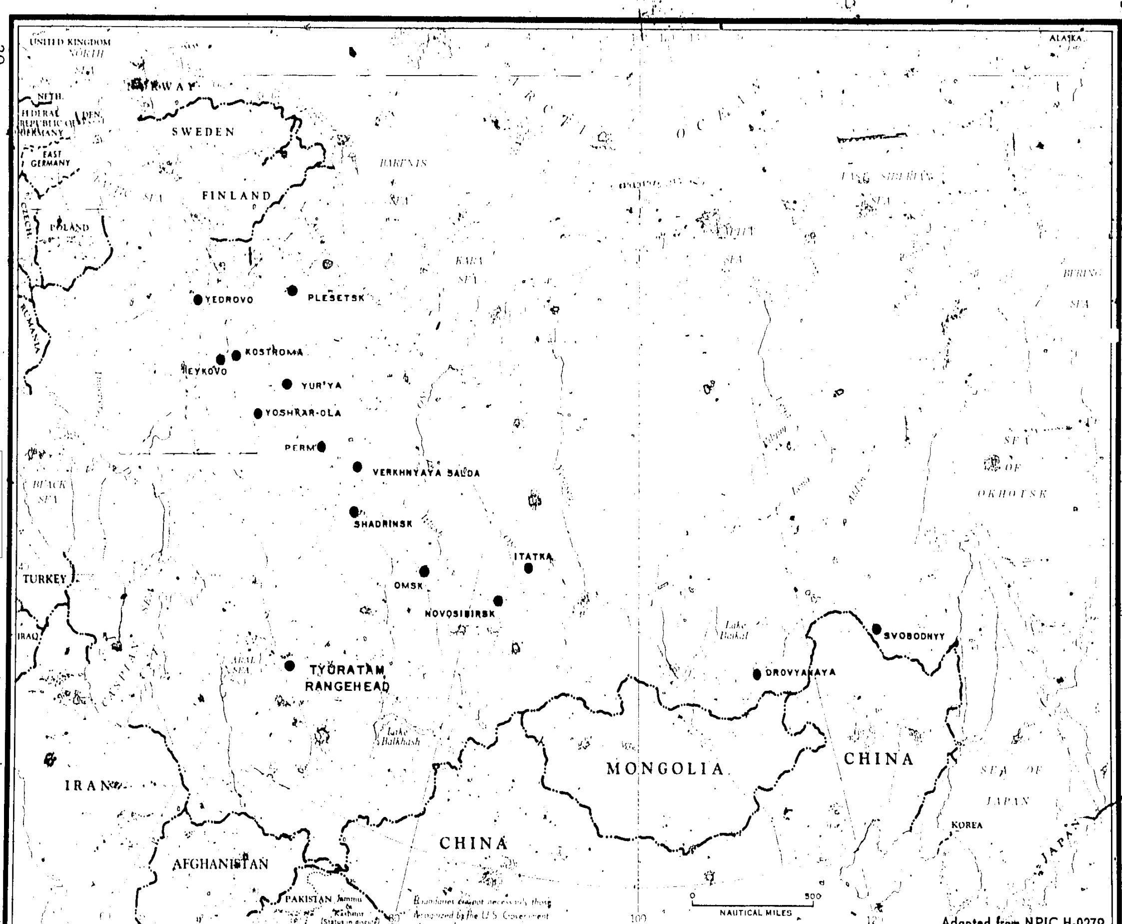

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Figure 16
SS-7 DEPLOYMENT, OCTOBER 1962

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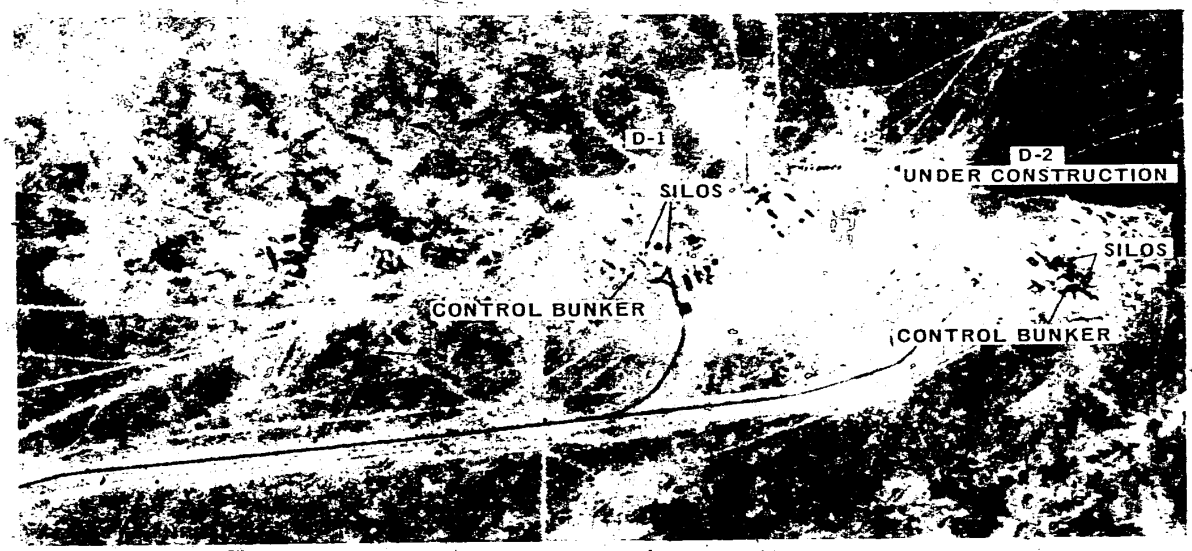

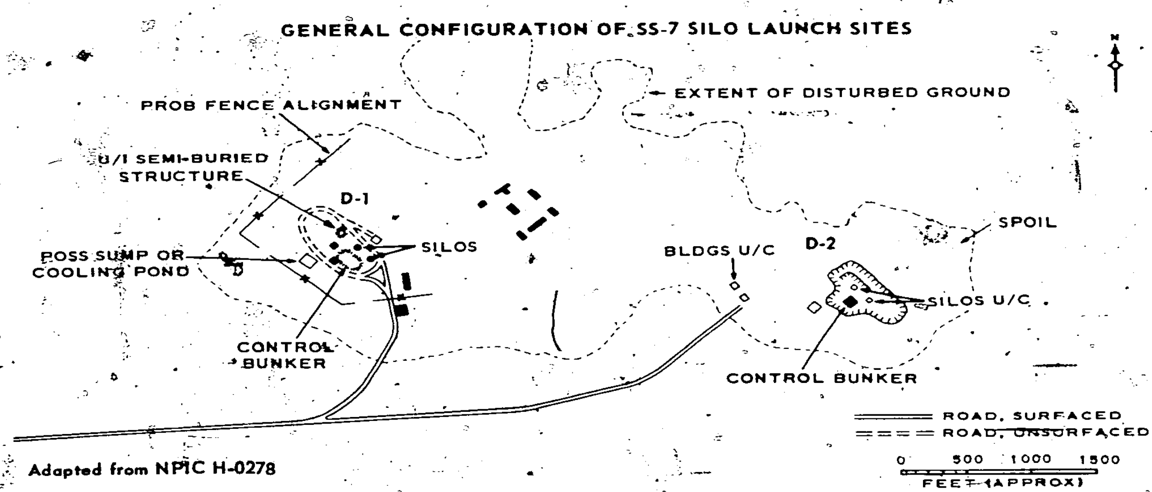

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Figure 17
LAUNCH AREA D, TYURATAM MISSILE TEST RANGE

Construction activity was first observed at launch complex D in photographic coverage in December 1960. Photographic data has also uncovered the fact that similar, but not exactly identical, launch sites are under construction at Plesetsk, Yur'ya, Kostroma, Verkhnyaya Salda, Shadrinsk, Omsk, and Novosibirsk. (See figure 16.) The simultaneity of construction indicates that a maximum degree of concurrency is associated with the development and deployment of this system. Several conclusions are suggested by study of the construction schedule for the silo launchers at launch complex D, TTMTR, and similar deployment sites:

a. Photographic coverage during the construction of the launch facility indicates that the launch system, whether fly-out or lift, must be relatively simple by virtue of the relatively short time allotted for equipment installation and checkout.

b. The decision for deployment of the SS-7 vehicle in a silo mode must have been made in the spring of 1960, at least 6 months before the SS-7 flight program started.

c. On the basis of an 18-month average construction cycle, it appears that all known bases and operational sites covered will be ready for activation as follows:

TT area D-1	October 1962
TT area D-2	May 1963
Plesetsk C	December 1962
Kostroma E	1963
Novosibirsk B	1963
Novosibirsk C	1963
Omsk A	1963
Omsk B	1963
Shadrinsk B	1963
Verkhnyaya Salda F	1963
Verkhnyaya Salda G	1963
Yur'ya E	October 1962
Yur'ya G	1963

The silo-type launch complex control blockhouse is large enough to comfortably house the ground equipment and utilities that would be required for the two silo launchers. The diameter of each of the launcher structures is adequate for launchers of the lift or fly-out type. It is not possible to specify at this time which type is installed or whether or not a propellant loading system is incorporated in each silo or in the blockhouse. The dimensions of the structures, nevertheless, are adequate for any of the above arrangements if non-cryogenic propellants are used. The 18-minute interval for the 5 October 1962 launches is not restrictive in terms of launcher type or propellants. Examination of the construction sequence strongly suggests that the actual launcher systems regardless of type are installed concurrently with the silo construction. This implies a simple, possibly prefabricated, launcher system. It is not possible with the information available to accurately estimate the hardness level of the silos. However, if spacing between complexes is used as the criteria, the separation of the hard launch complexes of approximately 5 nautical miles at the operational sites would indicate an intent to harden to greater than 300 pounds per square inch.

The 6,000-nautical-mile (non-rotating earth) range of this missile was demonstrated during the September-October 1961 tests to the mid-Pacific area, an easterly firing distance of 6,500 nautical miles. It is believed that this represents the maximum range of the system since telemetry analysis disclosed that only enough propellant remained for about one more second of engine operation.